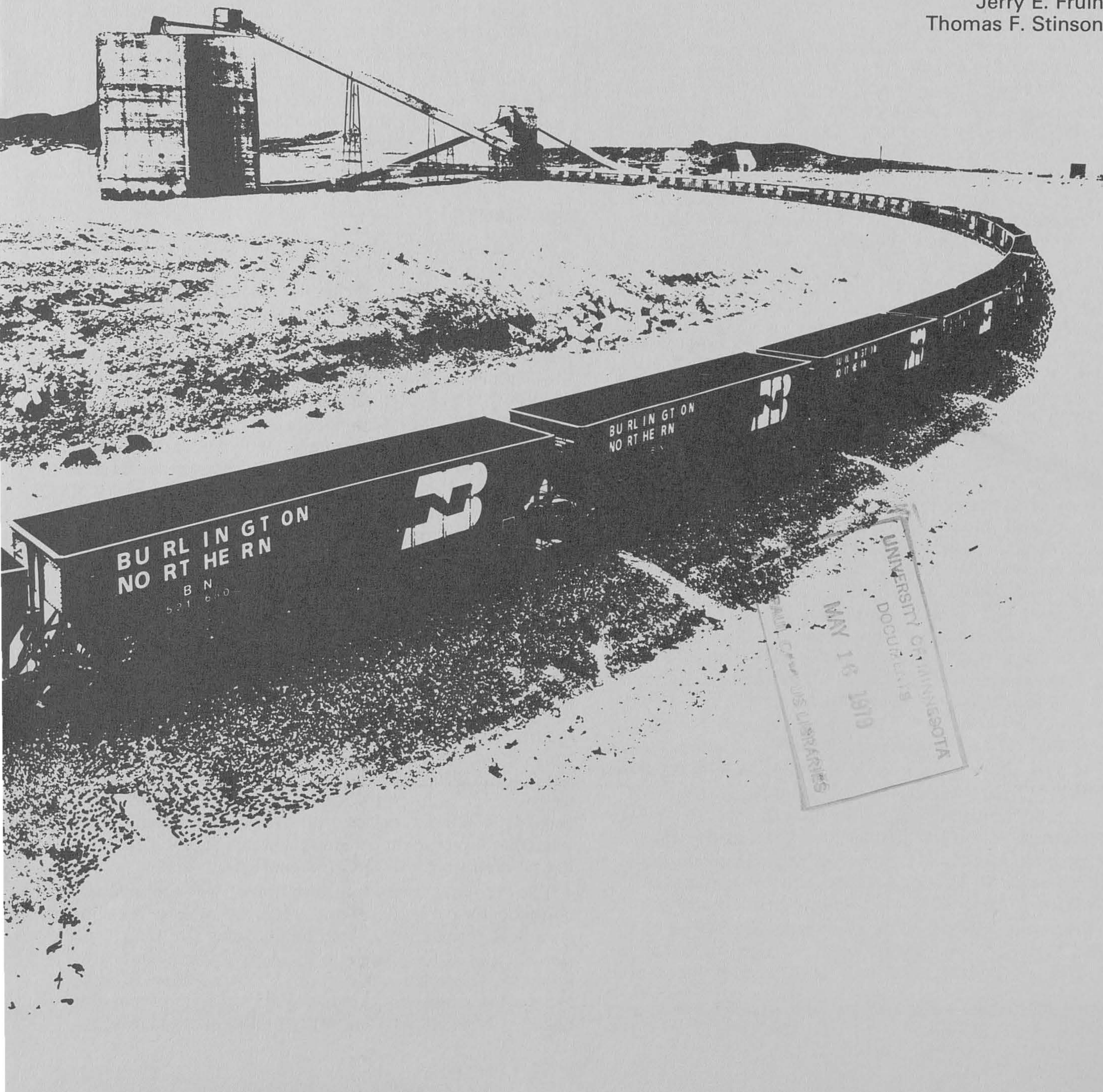
Extension Folder 451—1979
Agricultural Extension Service
University of Minnesota

MINNESOTA AND WESTERN COAL: Requirements, Costs, and Implications

Jerry E. Fruin
Thomas F. Stinson



The Economics, Statistics and Cooperatives Service and the Cooperative States Research Service of the U.S. Department of Agriculture; the Minnesota Department of Energy; and the Office of Research and Development, Energy Minerals and Industry, U.S. Environmental Protection Agency provided funds for this research. The views expressed are those of the authors and not necessarily those of the supporting agencies.

SUMMARY

Western coal (coal from Montana, North Dakota and Wyoming) is rapidly becoming a very important source of energy for Minnesota residents and industries. Its cost and the changes in the energy production, transportation, and distribution systems needed to assure reliable supplies are of vital concern to all Minnesotans. In addition, the shipment of large quantities of this coal through Minnesota will have an impact on Minnesota communities.

The first part of this publication discusses the demand for coal in Minnesota through 1985. The next section discusses the mining process and mining costs. This is followed by a discussion of the transportation costs of western coal to and through Minnesota with the final section presenting some implications of the increase in western coal use for Minnesotans.

Minnesota will require over 25 million tons of coal in 1985 compared with 13.2 million tons in 1976. Eighty-three percent of this coal will be used to generate electricity. The costs of western coal at a large efficient mine typically run from $7.50 to $8.50 per ton. Taxes account for 20 to 30 percent of the cost at the mine while reclamation costs are less than 1 percent. Transportation costs from the mine are frequently more than the cost of mining the coal. Unit trains (described later) are the most efficient method of overland coal transportation. Community problems due to unit coal train traffic are generally similar to those caused by other types of train traffic. Unit trains have tended to increase the awareness of and aggravated existing problems such as auto/rail conflicts.

The increases in the consumption of western coal will continue for at least several years because of existing contracts, long-term commitments, and the long leadtimes required for change in the capital intensive energy industry. There are uncertainties about increases in western coal consumption beyond 1985 because of possible changes in air quality and other pollution standards.

MINNESOTA AND WESTERN COAL REQUIREMENTS, COSTS, AND IMPLICATIONS

Jerry E. Fruin and
Thomas F. Stinson *

INTRODUCTION

The costs, transportation, and distribution requirements of western coal are increasingly important to Minnesotans. Between now and 1985 the state can expect:

- Coal will provide a higher proportion of the state's basic energy needs than in the recent past. The decline in the availability of natural gas and Canadian crude oil, and the associated price increases will stimulate increased use of coal by the state's industry.
- Western coal (coal from Montana, North Dakota, or Wyoming) will secure a larger share of the market for coal in Minnesota. While the quantity of coal obtained from midwestern sources such as Illinois and Kentucky may not decrease, existing contracts and plans insure that western coal will be used increasingly.
- Coal movement through Minnesota to points in other midwestern and eastern states will increase. Minnesota is on a major rail route from the western coal mines and at the head of navigation on the Great Lakes and the Mississippi River. For the enormous projected increases in coal production to become reality, additional coal traffic must be routed through Minnesota.

This publication discusses four aspects of the coal situation in Minnesota. Estimates of the expected increase in coal usage in Minnesota are provided, followed by a section describing the mining process and the costs of producing western coal. The transportation and distribution system for western coal and transportation costs are then discussed. The publication concludes with a discussion of the implications of increased western coal use for Minnesota residents.

Table 1. Actual and projected coal use in Minnesota

Use	1976 Actual		1980 Projected		1985 Projected	
	tons	%	tons	%	tons	%
Electricity generation	10,871,663	82.4	14,261,224	81.9	21,203,730	83.3
Industrial users	1,527,794	11.6	2,243,394	12.9	3,310,304	13.0
Coke plants	647,000	4.9	647,000	3.7	647,000	2.5
All other	134,514	1.1	261,456	1.5	317,148	1.2
Total	13,180,971	100.0	17,413,074	100.0	25,478,182	100.0

Source: The Minnesota Coal Study, A Final Report to the Legislature (Review Copy), Minnesota Energy Agency, July 1978.

MINNESOTA COAL REQUIREMENTS

The Minnesota Energy Agency surveyed all known coal users to determine actual coal use in 1976 and projected use requirements for 1980 and 1985. It also projected coal use in 1980 and 1985 for potential coal users, including facilities currently receiving natural gas on an interruptible basis. [6,7,8] These projections are summarized in table 1. The Minnesota Energy Agency found that 13.2 million tons of coal were used in 1976. Minnesota's projected requirements are 17.4 million tons in 1980 and 25.5 million tons in 1985, increases of 32 percent and 93 percent respectively, over 1976. Projections do not include coal passing through Minnesota for users in Wisconsin, Michigan, Iowa, and Illinois, nor the 2.5 million additional tons of coal required if all industrial use of natural gas were curtailed.

Electric utilities required 82.4 percent of the coal used in 1976. In 1985, utilities are projected to use 83.3 percent. There were 32 coal burning utility locations in 1976 with coal consumption ranging from 750 tons at Moorhead to over 2,400,000 tons at the Northern States Power (NSP) Plant in Sherburne County. There are 36 probable coal burning electric generating locations in 1985, according to these projections. The largest is the NSP complex near Becker with a planned consumption of 7,254,000 tons. The only completely new site is the planned Minnesota Power and Light (MP&L) plant at Floodwood, which has a projected coal consumption of 2,350,000 tons when completed.[1] Only 12 of the utility locations used more than 100,000 tons of coal in 1976 while only 15 utility locations are projected to use more than 100,000 tons of coals annually by 1985. Two utilities, Northern States Power and Minnesota Power and Light used over 70 percent of the total coal in Minnesota in 1976 and are projected to use almost the same percentage in 1985.

Industrial users (except for coke and gas plants) consumed 1,527,794 tons in 1976. This consumption is projected to increase to 3,310,304 tons in 1985, an increase of 116 percent in 9 years. But industrial use as a percentage of total coal use in Minnesota is projected to increase only slightly from 11.6 percent in 1976 to 13.0 percent in 1985.

The largest industrial coal users are the mining companies on or near the Iron Range and the sugar beet processors in or near the Red River Valley. The largest

*Jerry E. Fruin is an extension specialist, transportation, and an assistant professor, Department of Agricultural and Applied Economics, University of Minnesota. Thomas F. Stinson is an economist, Economics, Statistics, and Cooperatives Service (ESCS), U.S. Department of Agriculture, stationed at the University of Minnesota.

[1]Completion of this plant was originally scheduled for 1984, but is now scheduled for 1986.

numbers of coal burning plants (but not in quantity of coal burned) are in the food processing industries.

The survey identifies 33 sites where coal may be used by industry in 1985. Coal was used at 27 of these sites in 1976. However, coal consumption at nine of these sites is projected to continue to be less than 1,000 tons in 1985. Two other sites used less than 1,000 tons in 1976 and are projected to use less than 5,000 tons in 1985. There are nine industrial users projecting 1985 usage of 100,000 tons or more with the largest user projected at 1,250,000 tons. Three locations with no 1976 coal use are projected to use over 100,000 tons each in 1985.

Two coking plants are located in Minnesota. Their percentage of coal use in the state is projected to drop from 4.9 percent in 1976 to 2.5 percent in 1985.

The other actual and potential coal users identified consumed only 1.1 percent of the coal used in Minnesota in 1976 and are projected to consume 1.2 percent in 1985. Only one of these users, the University of Minnesota's Minneapolis Campus, is projected to consume over 100,000 tons of coal in 1985.

In addition to the coal consumed by Minnesota users, increasing amounts of western coal will pass through Minnesota. This increase is primarily because low sulfur western coal can meet air pollution standards with less treatment than coal from traditional sources.

Table 2 lists the major eastward movements of western coal through Minnesota to other midwestern states. These shipments are projected to more than double to a total of 15,900,000 tons by 1985. This will be more than 62 percent of the coal consumed within the state in that year.

Table 2. Coal passing through Minnesota to eastern points

	Amount (1,000 tons)		
Destination	1975	1980	1985
Port of Superior, WI	4,500	7,500	10,000
Wisconsin Utilities	2,000	3,200	4,900
Peoria, IL	1,000	1,000	1,000
Total	7,500	11,700	15,900

Source: Minnesota Coal Use and Projections: 1976-85 Minnesota Energy Agency, December 1977.

PRODUCTION OF WESTERN COAL

Although coal is not mined in Minnesota there are significant public policy issues concerned with the mining process and development. Severance taxes and reclamation requirements can influence both the source and cost of the coal consumed in Minnesota. This section describes the mining process and develops the costs associated with production, preparation and handling, taxes, and land reclamation.

Western strip mines are large, high volume operations. By 1985 average annual production in Wyoming is expected to exceed 5 million tons per mine, with some mines producing more than 20 million tons per year. These production levels are in sharp contrast to the underground mines of Appalachia where normal output is less than 2 million tons per year, and many mines produce less than 20,000 tons annually.

Production is high in the Northern Great Plains because coal seams are thick and relatively near the surface. Stripping ratios (the ratio of the thickness of the overburden to that of the coal seam) of under 2 to 1 are not uncommon, and coal seams range up to 80 feet in thickness. In contrast, a stripping ratio of 12 to 1 is usually sufficient for development in midwestern strip mines, and seams under 3 feet thick often are worked in underground mines.

Western coal's advantages, in addition to low sulfur content, are all related to seam thickness. Mining costs are lower because large draglines and coal shovels can be used, greatly increasing output per worker hour. Reclamation costs also are lower because only a few square feet of surface area is disturbed per ton of coal extracted. Western coal's disadvantages are relatively low heat content (ranging from 6,500 Btu per pound for lignite to 9,000 Btu per pound for sub-bituminous compared with 10,000 to 14,000 Btu per pound for eastern coal) and the shipping distance to reach major market areas.

Each strip mine in Montana, North Dakota, and Wyoming has different seam thicknesses and overburden depths, but the general characteristics of the mines are similar. A description follows of a mine typical of those currently in operation.[2] This hypothetical 5 million ton per year mine is the basis for the following estimates of production costs, reclamation costs, and taxes.

Production Costs

Strip mining is a continuous process. Some land is mined while other areas are being prepared for stripping and still others are being filled, regraded, and seeded. All these activities are underway at all times (figure 1), but for clarity the mining process is described sequentially here.

Mining begins with topsoil removal using large pan scrapers. Reclamation regulations require that topsoil be stockpiled separately from other overburden, so that it may be spread back as mining is completed. The mine then progresses in a series of long parallel cuts with the overburden from the new cut being placed in the previously mined cut.

After the topsoil is removed, the overburden must be drilled and blasted with a combination of ammonium nitrate and fuel oil (called anfo). An electric powered dragline with a bucket capacity of 41 cubic yards is used to remove the loosened overburden. Larger draglines operate in some areas.

After removing the overburden, the exposed coal seam is blasted (again using anfo). The loose coal is loaded by electric coal shovels, equipped with 26 cubic yard dippers, into 70-ton capacity coal hauling trucks to be taken to the preparation plant. The thickness of the seam forces blasting and mining in two stages, each taking about 26 feet of the coal seam's depth.

The cost of mining coal under these conditions averages about $5.15 per ton, much of which is due to initial equipment costs. The dragline itself costs more than $5 million and takes one year to assemble; coal shovels each cost more than $1.3 million. The cost of the initial mining equipment for the 5 million ton per year mine was estimated at more than $12.8 million in 1976. Today, it would

[2]More detailed descriptions of coal mines typical of the Northern Great Plains may be found in [9] and [11].

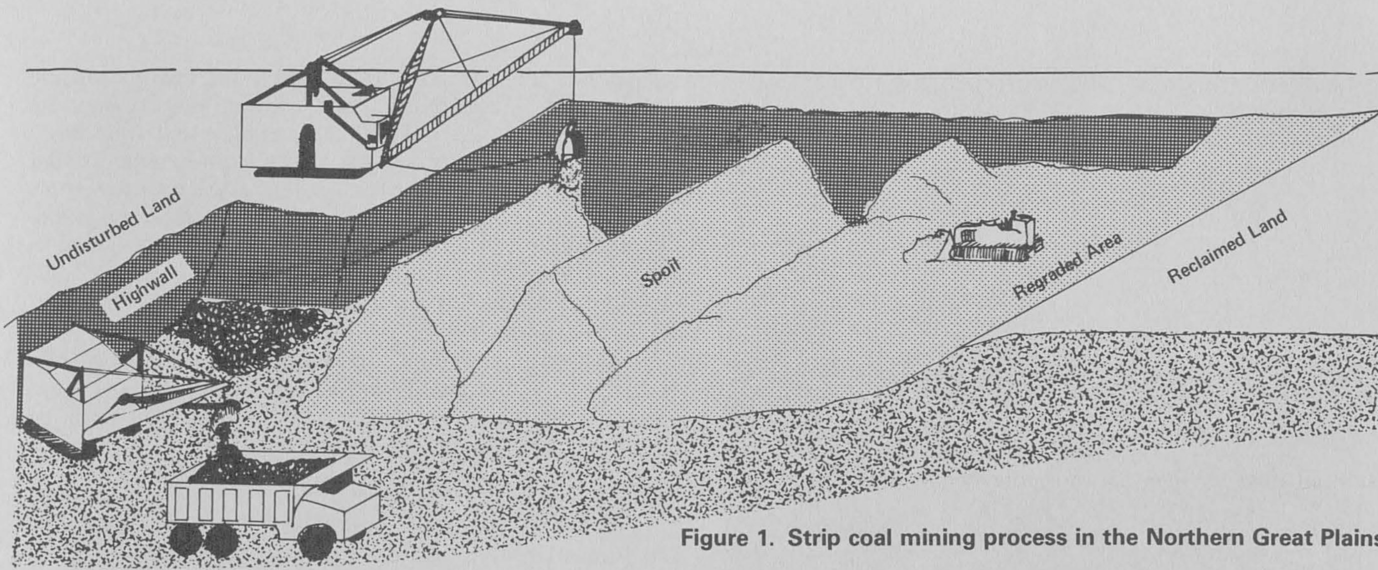


Figure 1. Strip coal mining process in the Northern Great Plains.

be even more. In contrast, direct labor costs were estimated at only $2.6 million per year. Supplies, power, royalties, and other miscellaneous costs were estimated at approximately $7.4 million per year.

Reclamation Costs

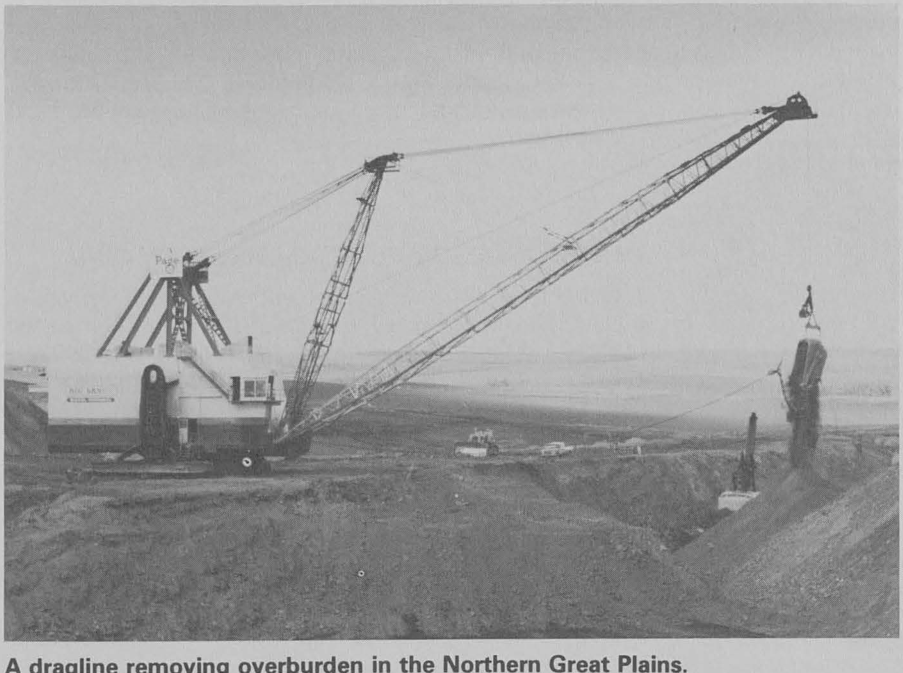
After the coal removal, the dragline fills the strip already mined with the overburden from the next strip being opened. The filled area is then regraded by large bulldozers, establishing the contours required by the mining permit. The topsoil is replaced and the area reseeded with a hydroseeder to approved grasses and legumes. The seed and fertilizer slurry and a straw mulch are applied in one continuous operation.

Costs of reclamation vary according to terrain. Areas with relatively large amounts of overburden to be moved and recontoured are, of course, more costly to reclaim. The estimates in table 3 illustrate the relative costs of the various reclamation operations. Differences among the three sites are primarily due to the depth of topsoil that must be replaced.

Table 3. Estimated reclamation costs by location

Location	Recontouring	Topsoil	Reseeding	Other	Total
			$/acre		
Decker, Montana	1,500	2,400	175	300	4,375
Beulah, North Dakota	1,500	2,950	138	275	4,863
Belle Ayre, Wyoming	1,500	700	200	400	2,800

Source: Leathers. [5]

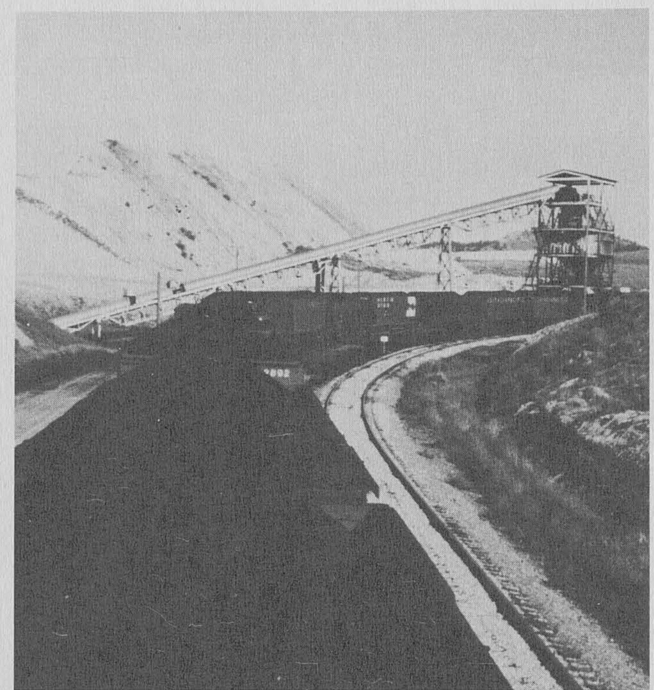

A dragline removing overburden in the Northern Great Plains.

Per acre reclamation costs appear large, especially when compared to the land's average market value of $300. But they are small per ton of coal mined. For example, 1 acre with a 52-foot coal seam yields approximately 87,000 tons of coal. As a result, estimated reclamation costs would be 5 cents a ton at Montana and North Dakota sites, and 3 cents a ton in Wyoming. A seam thickness and coal yield of half that would double the cost per ton, but would still be substantially lower than the reclamation costs of several dollars per ton common to strip mines in Appalachia.

Taxes

Taxes are the third major component of mining costs. Federal, state, and local taxes all must be paid and are a significant operating cost. State and local tax bills vary depending on the rates at which local property taxes are levied. Federal taxes are assumed to be the same at all locations.

State taxes are highest in Montana amounting to $1.64 per ton for the example mine. This is due primarily to Montana's coal severance tax, which at 30 percent of contract



Coal train passing under the tipple.

sales price, is the highest in the nation. While North Dakota and Wyoming receive considerably less than Montana, state revenues still are sizable. Local governments receive much less. In North Dakota local taxes amount to less than one cent per ton, primarily because the gross proceeds from the mine are not included in the local property tax base as they are in Montana and Wyoming[3] (table 4).

Federal taxes, which include the federal reclamation fee, the black lung levy, and the corporate income tax, are estimated to total 90 cents per ton. Since most western coal mines are owned by corporations active in other mining or energy production ventures, the actual amount paid depends on the overall profitability of the corporation and not on that of a single mine.

Table 4. Estimated tax costs by state

State	State taxes	Local taxes	Federal taxes	Total
		$/ton		
Montana	1.64	.09	.90	2.63
North Dakota	.91	.002	.90	1.81
Wyoming	.62	.38	.90	1.90

Preparation and Loading Costs

Coal is trucked from the mine to the preparation plant where it is crushed to a maximum diameter of 2 inches. A typical plant, costing more than $5 million, is capable of crushing and preparing more than 2,000 tons per hour. The crushed coal is then stored in large silos, before being loaded into railroad cars.

Most western coal shipments are made using unit trains, sets of locomotives and cars which remain together in a continuous cycle from the mine to the destination and back again. While these trains vary in length, they are often made up of about 100 cars. Such a unit train has a capacity of 10,000 tons of coal. The train is pulled under an overhead bin or tipple for loading. The train crew spots the first car (positions it) for loading. A pacesetter maintains a uniform train speed and the cars are top loaded as they pass under the tipple. Some facilities can load 4,000 tons per hour or one car every 2 minutes.

To take advantage of unit train shipments, a substantial investment must be made in loading and unloading facilities. The loading facility used in this example cost more than $3.8 million. Preparation and loading adds about 85 cents per ton to the cost of the coal.

Summary of Production Costs

The major costs associated with coal production in the Northern Great Plains are summarized in table 5.

Table 5. Estimated production costs at three Northern Great Plains locations

Type of cost	Decker, Montana	Beulah, North Dakota	Gillette, Wyoming
		$/ton	
Production	5.15	5.15	5.15
Reclamation	.05	.05	.03
Taxes	2.63	1.81	1.90
Preparation and loading	.85	.85	.85
Total cost FOB mine	8.68	7.86	7.93

Three items stand out:

- Reclamation costs are a very small part of total costs. Even if these estimates are five times too low, reclamation costs would be less than 25 cents per ton and account for less than 3 percent of total mining costs.
- Taxes, however, have a noticeable effect on the price paid for coal at the mine. In Montana, taxes may account for more than one-fourth of the final loaded-for-shipment costs.
- Preparation of the coal and loading it for shipment are also significant costs. Coal handling and preparation is an expensive and often overlooked cost to the final consumer.

TRANSPORTATION COSTS OF WESTERN COAL

Geography has had a major influence on the development of Northern Great Plains coal. The major population centers and their accompanying demands for energy are a considerable distance away, close to fields of higher Btu coal. As a result, although coal in the eastern areas is more costly to mine, the final delivered price to the utility plant or factory can be lower, especially when judged in terms of heat content, i.e., on cost per million Btu's. The cost of transporting coal from the mine to the consumer makes the difference.

Just as the development of massive strip mining equipment made possible large scale mines with low production costs, the development of unit trains has lowered transportation costs.

[3]A more detailed analysis of the taxes paid by coal mines may be found in Stinson and Voelker. [10]

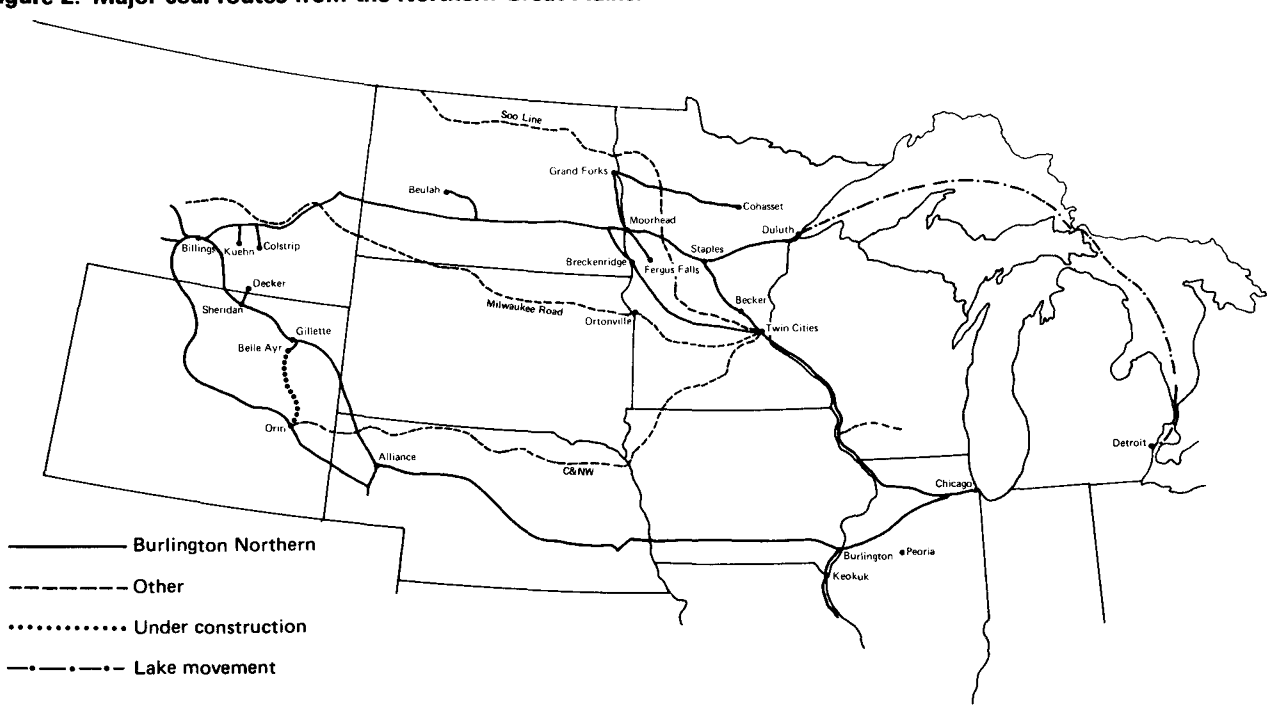
The unit train is a very efficient method of moving bulk commodities. In the ideal situation, a unit train is a dedicated set of locomotives and cars that remain together in a continuous cycle from origin to destination and back again. Such a train only slows down for loading and unloading and stops only for fueling, crew changes, and inspections. High speed loading and unloading facilities are required. Uncoupling and coupling of cars is unnecessary and "free time"[4] for loading and unloading is 4 hours or less at both origin and destination for trains of 100 or more cars. Operating costs are reduced because unit trains are scheduled to avoid or pass directly through terminals. Car switching enroute is unnecessary because all the cars have a common origin and destination.

Substantial cost savings are possible because equipment in unit train service is in constant use while equipment in regular service is frequently idle. The rail cars are always fully loaded or on the way back to reload. Locomotive requirements are known and vary only with the terrain as trainload weights are the same each trip. Paperwork and administrative costs can be greatly reduced for both the shipper and the railroad and labor and other costs of switching, yard and terminal operations are avoided by unit trains.

Nearly all the coal and lignite shipped from Montana, northern Wyoming, and North Dakota moves by rail, primarily by unit train. One railroad, the Burlington Northern (BN), dominates this movement. Figure 2 shows how mainlines of the BN service the Northern Great Plains coal fields. One line goes southeast starting near Billings, Montana through Gillette, Wyoming to Lincoln, Nebraska. Spurs on this line service the large mines at Decker, Montana and Belle Ayr, Wyoming. The northern route which has a spur to Colstrip serves: Minnesota users, the Great Lakes transfer point of Duluth-Superior, and the Mississippi River transfer point of Minneapolis-St. Paul. The southern route, through Gillette, provides access to the Mississippi River at such points as Keokuk, Iowa and St. Louis, Missouri as well as access to the Ohio River at Metropolis, Illinois. The route also interchanges with another line at Peoria, Illinois, providing access to the Illinois River. The BN also has lines to major lignite mines in North Dakota.

While other railroads participate in the movement of Northern Great Plains coal, their activity is, at present, of secondary importance. The Milwaukee Road takes some unit coal trains that originate on the BN to midwestern destinations but its line is generally north of the major coal development. The Soo Line has lines to or near the North Dakota lignite fields and has participated in lignite movements but its main lines are east of the major Montana and Wyoming mines. The Chicago and Northwestern Railroad (C&NW) routes are south and east of the coal fields. The C&NW will gain access to several large mines in the Belle Ayr, Wyoming area. The C&NW and the BN are constructing a new line from the south near Orin, Wyoming to Belle Ayr. The C&NW's mainline east through Nebraska will require major upgrading before it can develop unit train coal traffic to the Midwest.

Figure 2. Major coal routes from the Northern Great Plains.



---

[4]Free time is the time allowed before charges are made by the railroad for the delay of equipment.

Transportation Costs to the Twin Cities

The costs of shipping coal to Minneapolis/St. Paul from alternative mine sites are given on both a dollars per ton and a cents per million Btu basis for comparison (table 6).

Table 6. Transportation costs to Minneapolis/St. Paul

Origin	Single car rate $ per ton	Trainload rate $ per ton	Trainload rate ¢ per million Btu's
Colstrip, MT	$14.06	$ 7.61	47.6
Decker, MT	16.53	9.71*	60.9*
Gillette, WY	——	10.53*	65.8*
Beulah, ND	8.13	5.92*	45.5*

*Estimated

These are based on actual shipping costs paid by users in 1977. Where a quoted rate was available that rate was used. [3] When actual rates were not published, costs were estimated by taking the quoted rate for a shorter shipment and then adding a fixed charge per ton mile for the remaining distance. When available, both trainload and single car rates are presented.

The trainload rates to the Twin Cities are considerably less than single car rates, but more than unit train rates would be because automatic dumping equipment is not available in the Twin Cities. Trains must be broken down and 24 hours is allowed for unloading. A minimum annual shipment volume of 1.1 million tons per year is required for the trainload rate.

North Dakota lignite appears to have a significant advantage over Montana and Wyoming sub-bituminous coal when judged on cost per ton. However, when analyzed on cost per million Btu's, that advantage is reduced. The lower heating value of lignite greatly limits the distance it can economically be shipped. In addition, lignite is less stable than sub-bituminous coal and has the potential for spontaneous combustion. Consequently almost all plans for additional uses of North Dakota lignite involve converting it to other forms of energy at or relatively near the mine site.

Transportation costs between Colstrip and the Twin Cities are the lowest of the sub-bituminous rates considered. Transportation costs are only slightly less than the FOB mine price, causing the delivered price to be nearly twice the mine price. In fact, production costs amount to only 32 percent of the cost at Minneapolis, taxes account for 16 percent of the cost, preparation and loading costs account for 5 percent, while transportation accounts for 47 percent of the cost (figure 3). Transportation costs account for 53 percent of the cost of Decker coal in the Twin Cities and 57 percent of the cost of Gillette coal in the Twin Cities.

Barge Transportation from Minneapolis-St. Paul

Some western coal is transferred from railcars to barges in the Twin Cities for shipment to users along the Mississippi River. Barge rates are generally lower than rail rates (.4 to .7 cents per ton mile compared to unit train rates of .9 to 1.2 cents per ton mile). However, if river transportation is used for only a short distance, or if the river route increases the distance the coal is shipped, an all rail movement may be cheaper. A key cost element is the terminal handling cost of from 60 cents to over $1 per ton, incurred whenever coal is transferred from one form of transportation to another.

A comparison of the unit train rate from Gillette, Wyoming to Alma, Wisconsin with the combined rail and barge rate through Minneapolis illustrates a situation where the rail barge movement is the higher cost mode (table 7). The reasons for the higher cost are the short barge haul and the unloading from train to barge. [12] Transportation costs account for 60 percent of the final delivered price in this example.

Table 7. Estimates of delivered price of coal by alternative transportation modes from Gillette, Wyoming to Alma, Wisconsin

Unit train	($)Costs	Percent of delivered costs
Cost of coal FOB mine	$ 7.93	41.2
Unit train to Alma	11.33	58.8
Final delivered price	$19.26	100.0
Train-barge combination		
Cost of coal FOB mine	$ 7.93	38.7
Trainload rate to Mpls.	10.53	61.3
Loading to barge	.80	
Towing	1.25	
Final delivered price	$20.51	100.0

Lake Shipments Through Duluth-Superior

Water transportation using the Great Lakes ports of Duluth, Minnesota and Superior, Wisconsin offers significant cost savings for shipping Northern Great Plains coal. One prominent movement is from Decker, Montana to Detroit. Coal moves from Decker by unit train to Superior, Wisconsin. There it is transferred to lake vessel for shipment to power plants in the Detroit area. Annual coal movement on this route is expected to exceed 7 million tons in 1980.

Total transportation costs for this 1,700 mile rail-laker movement is $14.25 per ton. [4] No unit train rate exists from Decker to Detroit Edison's plants but the existing unit train rate from Decker to Chicago, Illinois is $15.11. [1] Since Detroit Edison's plants are 300 miles farther east, rail costs (and rates) would be greater. Use of lake transportation yields an estimated savings of $5 per ton, even though the all rail route is approximately 100 miles shorter than the rail-laker combination.[5]

Transportation costs account for 62 percent of the total cost of coal to the utility (table 8). The actual cost of mining the coal accounts for slightly less than 23 percent. Taxes, the third major element of cost, account for more than 11 percent when all taxes (federal, state, and local) are included. This demonstrates the importance of transportation costs in determining the extent to which Northern Great Plains coal will be developed in the future.

[5]The estimated all rail cost is $19.28, i.e., 1,600 miles times $.012 per ton mile.

Table 8. Estimated coal costs from Decker, Montana to Detroit, Michigan

	($)Costs	Percent of delivered cost
Production	5.15	22.5
Reclamation	.05	0.2
Taxes	2.63	11.5
Preparation and loading	.85	3.7
Rail-laker transportation to Detroit	14.25	62.1
Total price	22.93	100.0

IMPLICATIONS FOR MINNESOTA

Coal transportation and distribution systems in Minnesota will be affected by both the increased demand for coal and its cost structure. First, there will be more coal users as the use of coal to provide basic energy increases. Many will be small users who previously relied on natural gas or oil. They will require periodic transportation of coal by surface modes such as barge, rail or truck. They will also have to develop suitable storage space. Since coal is bulky and unsightly, and a potential air and water pollutant, it may be necessary to establish new standards for small coal storage areas.

While many new coal users will be situated on railroads, some will not. But even railroad users will not necessarily have adequate facilities to handle coal. Thus, there will be an increased requirement for coal handling equipment such as over-the-road coal trucks, and conveyors and loaders for use in coal yards. There will be a corresponding increase in the number of heavily loaded coal trucks on specific highways, with possible impacts in terms of traffic congestion and increased road maintenance.

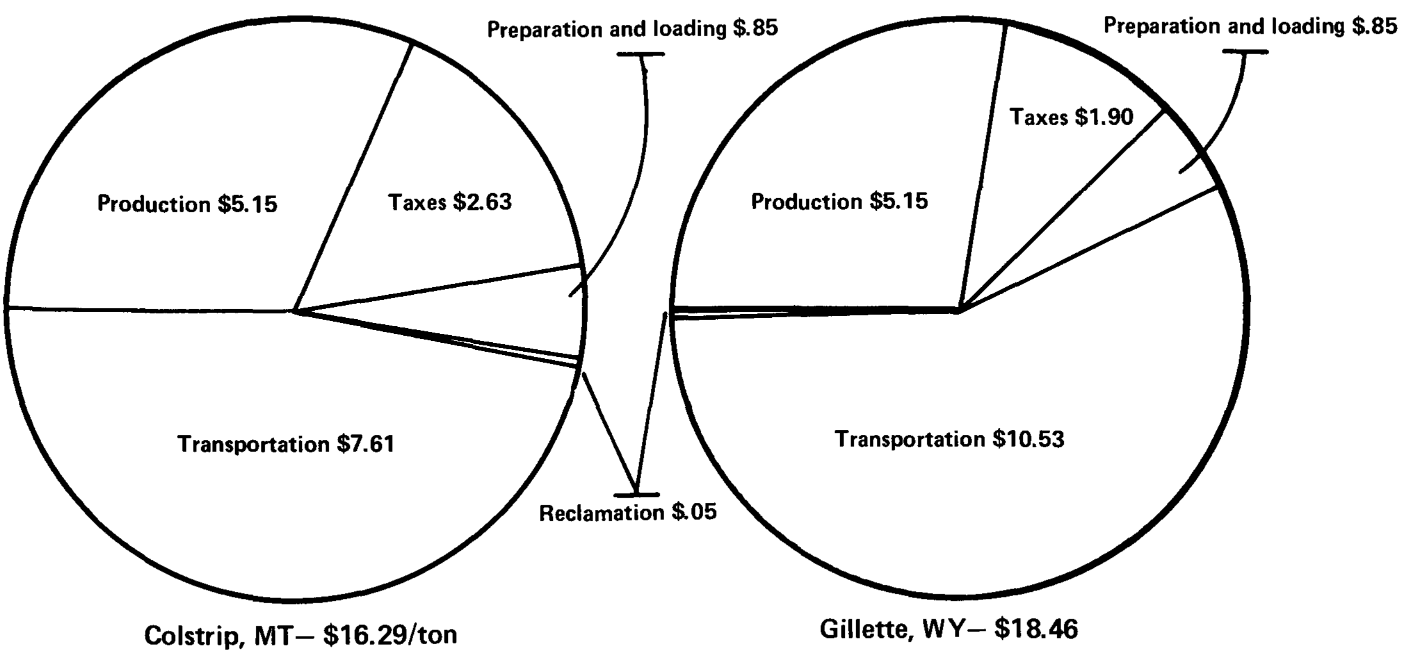
An important consideration for Minnesota energy and transportation specialists is how the transportation and distribution of coal to small users should be organized to minimize the total economic and social costs of the increased coal movement to small users. For example, should the state encourage the development of coal distribution centers with facilities to transfer coal from unit trains to trucks, or should direct rail shipments to each user be encouraged? If coal distribution centers are desired, where should they be located and how should they be publicly or privately financed?

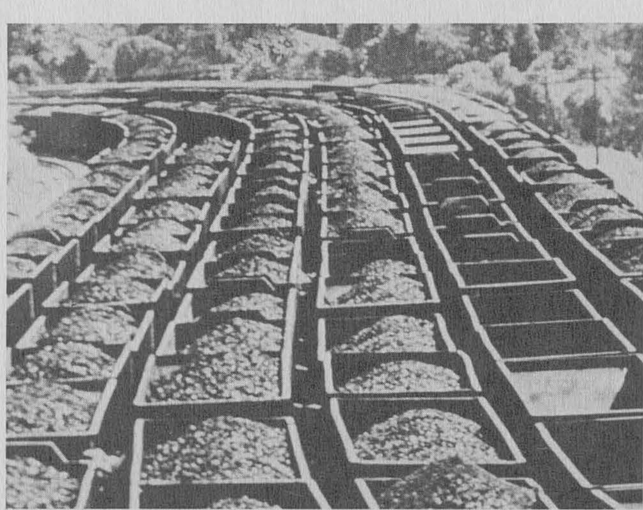
A second implication of increased use of western coal is that barge movements of coal to Minnesota from southern Illinois and points on the Ohio River system will increase little from present levels. At the same time, downstream movement of western coal by barge (which was virtually unknown a few years ago) could increase rapidly. This has important implications for grain shippers and other competing users of dry cargo barges. Currently northbound coal movements provide the Twin Cities area with barges needed for downriver traffic. As grain exports have increased, a larger proportion of barges have had to be shipped to the Twin Cities empty. If barge shipments of western coal increase, more empty barges will be needed and the downbound western coal will compete with grain for empty barges. The result will be an increase in the barge rates for downbound grain and coal relative to upbound barge rates for dry cargo. In turn, the increased barge rates will make midwestern coal more competitive in Minnesota and make Minnesota grain and products less competitive in U.S. and world markets.

If the amount of western coal requiring barge shipment down the Mississippi continues to increase, additional rail-barge transfer capacity on the river will also be needed. The capacity of existing transfer points is limited, although some of the limitations are due to environmental considerations rather than physical capacity limits.

A third implication—that eastbound movement of western coal on the Great Lakes will increase—has already become an established fact. Shipments of western coal

Figure 3. Comparison of mining costs in Colstrip and Gillette.





Five and a half unit trains of coal enter Minnesota daily.

out of Duluth-Superior were 4.5 million tons in 1976 and are estimated to reach 7.5 million tons in 1980 and 10 million tons in 1985. This not only represents a change in the primary direction of coal movement on the Great Lakes, but is also important in terms of sheer magnitude. Ten million tons is more coal than Minnesota consumed as recently as 1974. A few years ago Minnesota was at the end of the logistics system for eastern coal. It is now providing vital rail links and transfer points for coal shipments from the west.

Increased coal use will require more rail cars, locomotives, and coal handling equipment. There will also be requirements for additional coal unloading facilities and transferring equipment. The cost of a hopper car that can haul 100 tons of coal is over $35,000. Locomotives cost over $600,000. Modern coal unloading and handling facilities will cost from $10-$30 million at each location. Clearly there are major capital requirements that must be financed by either coal users or the railroads but will ultimately be paid for by the consumer.

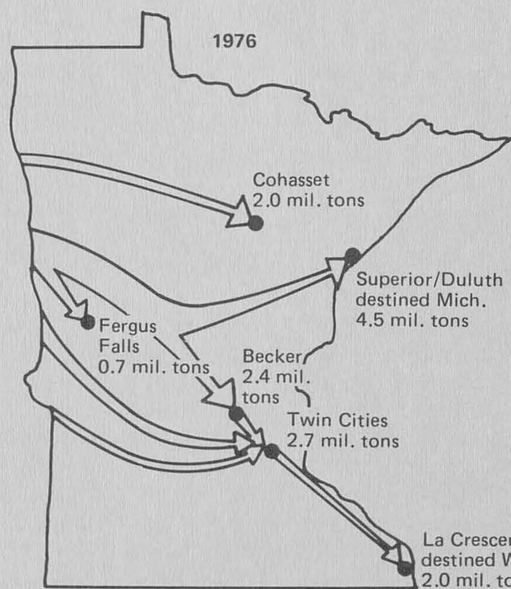
The final and possibly most important implication is that there will be huge amounts of coal being transported to and through Minnesota during the next 10 years. Because this is primarily "western" coal, it will be hauled in 100-car unit trains dedicated to coal use.

There are at most seven routes through western Minnesota suitable for moving heavily loaded coal trains. In fact, because of the locations of major mines, utilities, and transfer points on individual railroads, it is quite likely that most of the coal traffic will be concentrated on the routes through Minnesota shown in figure 4.

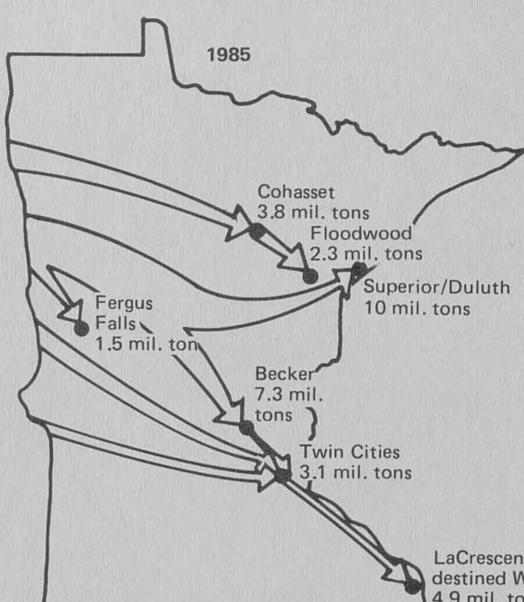
Currently, on the average, about 5.5 unit trains of coal enter Minnesota each day. But, the total number of daily unit coal trains is double that since the empty cars must be returned to the mines. Projections by the Minnesota Energy Agency indicate coal consumption in Minnesota will increase by 12 million tons, to a total of 25 million, in 1985. The 12 million tons of additional coal will require the equivalent of 1,200 unit trains or more than 3.3 unit trains per day in each direction. The Minnesota Energy Agency also projects that nearly 16 million tons of western coal will pass through Minnesota on the way to Wisconsin, Illinois, and Michigan, an increase of 8.5 million tons over 1976 levels. This increase would require an additional 2.3 unit trains each way per day. Consequently, it appears that there will be about 11 unit train round trips or 22 one-way trips per day in 1985 to and through Minnesota, double the 5.5 daily round trips which occur today.

The increasing movement of coal in unit trains adds to the existing train traffic on a few heavily traveled railroads. Communities located along these lines may experi-

Figure 4. Flow diagram of western coal in Minnesota—coal via unit trains only. (Courtesy Minnesota Department of Transportation)



SOURCES OF TONNAGE: Minnesota Energy Agency, "Minnesota Coal Use and Projections: 1976–85," and Northern States Power Company.



SOURCES OF TONNAGE: Minnesota Energy Agency, "Minnesota Coal Use and Projections: 1976–85," December 1977, and Northern States Power Company.

ence adverse impacts from the additional train traffic. Existing train traffic is often the major source of train problems. Coal trains accentuate existing problems and make these problems worse. A survey of communities in Minnesota along the major coal routes showed that the main concerns are grade crossing safety, the potential for blocked emergency vehicles, delays to automobiles at crossings, and train noise. [6]

The most notable community impact is the auto/rail conflict at grade crossings. This problem has been increasing not only because of increasing train traffic, but also because of increasing automobile and truck traffic on streets and highways.

BEYOND 1985

Future coal demands are based on projections which are subject to change. However, most of the coal use projected for 1985 is based on existing long term contracts and firm commitments. There are, however, valid reasons for questioning the economics of the continued rapid expansion of western coal use at eastern locations because of the high transportation cost per unit of energy. There are also alternative technologies for energy movement such as high voltage transmission lines, coal slurry pipelines, and on-site coal gasification. Pollution control policies and the continued availability of natural gas could also halt or delay the conversion of some small users to coal.

These factors could slow the long term growth of western coal consumption in Midwestern markets but would appear to have very little effect on the growth of western coal consumption between now and 1985. It is only a short time until 1985 considering the 35-40 year life span of power plants, transmission lines and pipelines and long-term (20 years) coal contracts. The effect of a slowdown in growth would only delay reaching the 1985 projected levels for a year or two.

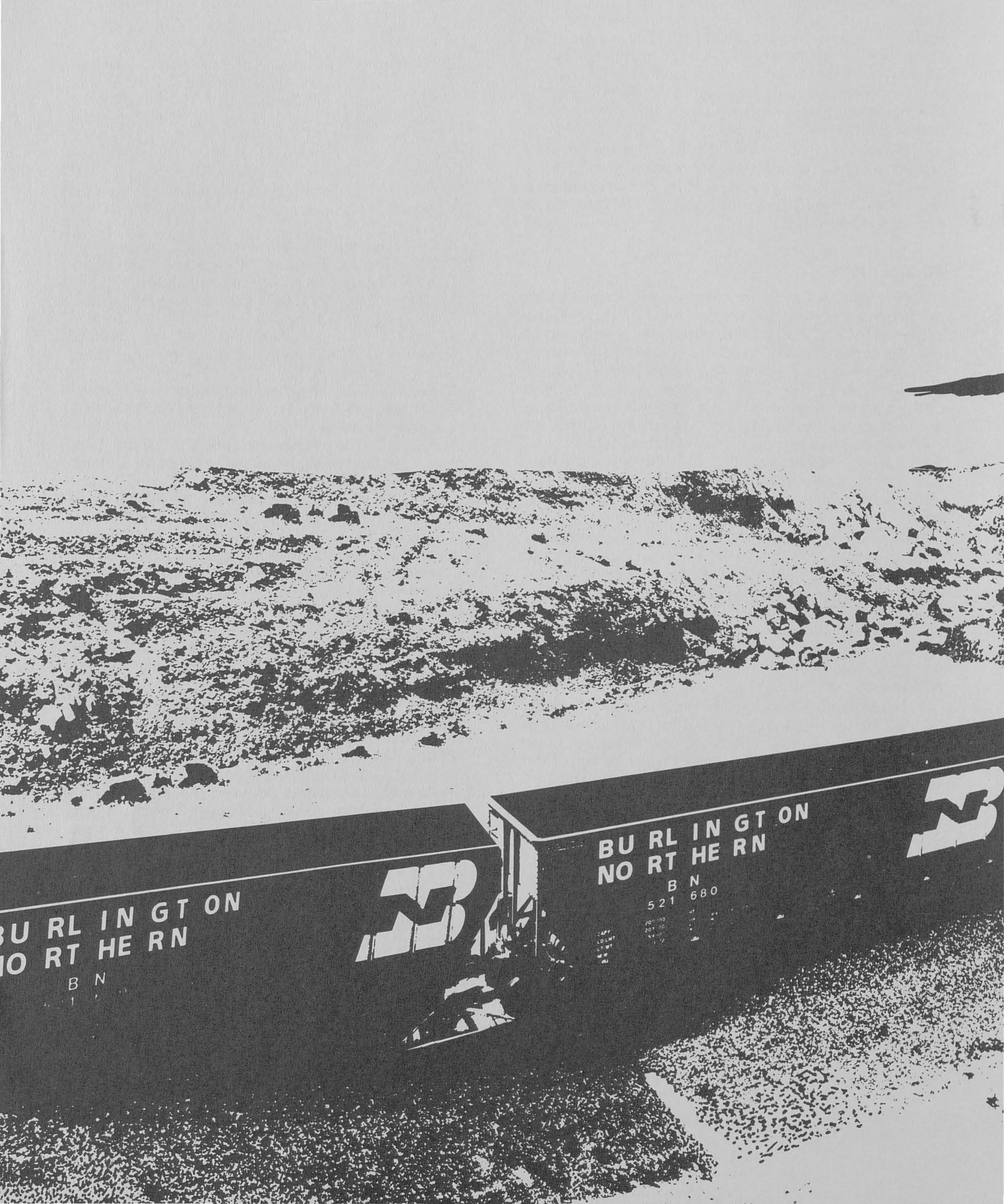
A factor that can conceivably cause a major change in the outlook for western coal would be drastic changes in air pollution regulations. This could take the form of either substantial relaxation of air quality standards or of the requirement that "the best available technology" be used to remove pollutants at all new power plants. These are conflicting proposals but both are currently under serious consideration, and one could be enacted. In the latter, there is no incentive to pay a premium for low sulfur coal if capital costs of emission controls cannot be avoided. In the former, there is no reason to pay the added transportation costs for low sulfur (and low energy) coal if coal supplies exist nearby.

However, even if one of the proposals becomes national policy, western coal production will continue to expand for several years because of contractual commitments, the time required to expand coal production in the east, and the increased reliance on coal generally because of reduced oil and natural gas supplies. Consequently, Minnesota and the Northern Great Plains states must expect that the recent increases in western coal consumption will continue. Solutions must be found for the stresses and problems caused by increased coal production, shipments, and consumption.

REFERENCES

1. Coal Week, McGraw-Hill, Inc., New York, N.Y., August 7, 1978.
2. Environmental Protection Agency, Rocky Mountain-Prairie Region, Region VIII, *Surface Coal Mining in the Northern Great Plains of the Western United States*, OEA 76-1, Washington, D.C.: Environmental Protection Agency, June 1976.
3. Fruin, Jerry E. and Robert Crnkovich, "Western Coal Transportation Rates for Minnesota Users," Staff Paper P78-3, Department of Agricultural and Applied Economics, University of Minnesota, April 1978 Revision.
4. Great Lakes Basin Commission, *Coal Transportation and Use in the Great Lakes Region*, Great Lakes Basin Commission, Ann Arbor, Michigan, 1978.
5. Leathers, Kenneth L., *The Economics of Surface Mining of Coal: A Case Study of the Western Region of the United States*, U.S. Dept. of Agr., Natural Resource Economics Div., NRED Working Paper No. 39, October 1977.
6. Minnesota Energy Agency, *Minnesota Coal Use and Projections: 1976-85*, St. Paul: December 1977 (Revised March 1978).
7. Minnesota Energy Agency, *The Minnesota Coal Study: An Interim Report to the Legislature*, St. Paul: January 1, 1978.
8. Minnesota Energy Agency, *The Minnesota Coal Study: A Final Report to the Legislature* (Review Copy), St. Paul: July 1978.
9. Skelly and Loy Engineers-Consultants, *Economics Engineering Analysis of U.S. Surface Coal Mines and Effective Land Reclamation*, U.S. Bureau of Mines, February 1975.
10. Stinson, Thomas F. and Stanley W. Voelker, "The Effects of State Taxation on Coal Mining in the Northern Great Plains," Proceedings Amer. Inst. of Min. Eng., Council of Economics, 1978(A), pp. 11-18.
11. Stinson, Thomas F. and Stanley W. Voelker, The *Impact of Coal Development on the Revenues of State and Local Governments in the Northern Great Plains*, U.S. Dept. of Agr. ESCS, Agr. Econ, Rpt. No. 394, January 1978 (B).
12. Wehrman, Chapman Associates, Inc. *Study of Proposed Coal Movements to Alma, Wisconsin*, Report prepared for Department of Justice, State of Wisconsin, February 1977.

Issued in furtherance of cooperative extension work in agriculture and home economics, acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Roland H. Abraham, Director of Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55108. The University of Minnesota, including the Agricultural Extension Service, is committed to the policy that all persons shall have equal access to its programs, facilities, and employment without regard to race, creed, color, sex, national origin, or handicap. 20¢


BURLINGTON
NORTHERN
BN
BURLINGTON
NORTHERN
BN
521 680